XI. *The Behaviour of* Coleoptera *in time of Floods.* By Norman H. Joy, M.R.C.S., F.E.S.

[Read April 6th, 1910.]

In the spring of 1905 when I first saw *Dianous coerulescens* alive in South Devon, I was much struck by the extremely rapid way it moved over the surface of a pool of water near which I found it. An examination of its mode of progression soon convinced me that it was not produced by any movement of its legs, and I was much puzzled until Commander Walker referred me to a paper which had shortly before been published in France. As this paper is of no great length, I think it best to quote it in full. It appeared in "Comptes Rendus Hebdomadaires des Séances et Mémoires de la Société de Biologie," 1905, tome second, pp. 102–3, and is entitled "Sur un mode particulier de locomotion de certains *Stenus*," par MM. G. Billard et G. Bruyant.

"Nous avons observé au bord des ruisselets alimentés par les sources pures et froides de la montagne deux espèces de *Stenus* (*S. tarsalis*, Lj., et *S. cicindeloides*, Schell.) qui présentent un mode particulier de locomotion à la surface de l'eau.

"Habituellement accrochés ils sont exposés à tomber sur la nappe liquide qui coule au-dessous d'eux, parfois avec une grande rapidité. Comme beaucoup d'autres insectes ils peuvent marcher à la surface de l'eau, mais leur vitesse de progression est alors très faible, et ils risqueraient ainsi d'être entraînés au loin. Pour lutter contre la rapidité du courant, ils usent du procédé suivant. Ils expulsent par l'extrémité anale une substance dont le contact avec la surface de l'eau produit une réaction qui les chasse très vivement en avant. L'animal peut en incurvant son abdomen orienter sa course vers le point qu'il veut atteindre. Nous avons cherché l'explication de cette locomotion speciale : elle réside pour nous dans les variations brusques de tension superficielle que provoque sur l'eau la substance expulsée par l'animal.

"Lorsqu'on place l'insecte à la surface d'une nappe d'eau

pure, sur laquelle on a projeté de la poudre de Lycopode, on voit les spores fuir en arrière de l'animal et celui-ci laisser un large sillage, lorsqu'il veut fuir rapidement : aucune réaction ne se produit au contraire, lorsque l'insecte marche simplement sur la surface. Si l'on détache l'extrémité de l'abdomen, on voit au bout de quelques instants celle-ci expulser par intermittence la substance à tension superficielle très basse, et se mouvoir rapidement comme un morceau de camphre ou de thymol."

* * * *

I have confirmed most of these observations with *D. coerulescens* and several species of the genus *Stenus*. My studies soon inevitably led me to the general study of the behaviour of Coleoptera during flood-time, as it must be chiefly at such a time that these powers of locomotion are brought into play. I have from time to time written notes on my observations which I hoped to publish when I had made a more complete study of the matter. However, from want of time, little progress has been made during the last two years, so I think it best to publish them in the hope that they may stimulate others to continue what is undoubtedly a very interesting subject.

When flat land or a river valley is flooded by heavy rains it is well known that a very large number of beetles and other insects is to be found in the "flood rubbish" washed or blown up at the sides of the water. It is also notorious how very local are some of the beetles inhabiting the banks of streams, and one wonders how it is these species are not washed away at every flood, or at any rate scattered all down the valley. I believe that as a fact most beetles soon find their way to land by various methods, and comparatively few, and those mostly of the larger species, get washed down the middle of the stream.

This can be proved by examining flood refuse caught on bridges, etc., in mid stream, and that blown up at the sides of the river. In the former large beetles predominate, very few small ones being found, whereas the latter generally teems with small insects. In some places the smaller beetles might be washed out of the mid-stream rubbish by the force of the current, but I have noticed that in the rubbish which collects over the arch of a bridge, when the whole arch is submerged, large beetles are found in greater numbers. It is chiefly due to the wind that the fine rubbish and small beetles so soon find the edge

of the flood. It is worth noting here how very soon many of the beetles leave this rubbish when it touches the ground on the subsidence of the flood. I make a rule now, when collecting flood refuse, of always taking it at the height of the flood, while it is floating on the water. From some rubbish fished out of the Kennet in 1908 I took about thirty specimens of *Ilyobates forticornis*. On collecting about the same quantity two days after, when the water had subsided and left it resting on the ground, only five or six more specimens were obtained. No doubt there is a large death-rate at every flood, some beetles soon succumbing to their wetting. It is difficult to account for the absence of certain species one would expect to find in the rubbish, particularly *Anchomenus albipes* and *Oodes helopioides*. The former is a very abundant riverside species, yet it quite seldom turns up in flood refuse. The latter I have never taken in this way, although it is a common species in the Kennet valley, and Commander Walker remarks on this (Ent. Mo. Mag., Vol. xliv, p. 135) with regard to the Thames.

But apart from the help of the wind many waterside beetles have other methods of reaching the shore quickly, viz. by swimming in various ways, walking on the surface of the water, and by this curious method described by MM. G. Billard and G. Bruyant, which, for want of a better term, I will call "skimming."

Now let us return to *Dianous coerulescens*. It is in this species that this method of progression is perhaps most easily watched, as it so readily performs it. When a piece of wet moss from near a waterfall is entirely immersed in water this beetle may sometimes be seen, covered with a glittering silvery layer of air, walking quite easily on the moss. At other times the beetle crawls to the outside of the moss and floats to the surface of the water, back uppermost, doubled up in the form of an inverted ∩, with the legs folded in front of the abdomen. The elytra first reach the surface and are soon free of the water. The thorax and head then clear the water and dry; the body is then straightened, with the apex pointing slightly upwards, the base of the abdomen sometimes taking some time to dry. Now the whole of the upper surface is above water and dry, the anal end being just at the surface, and the whole of the underparts and legs being under water. The beetle then generally starts off "skimming" at a most remark-

able speed, sometimes almost straight, sometimes in a series of curves. During the skimming the front legs are held either doubled up, or spread out, as in the position of a well "set" insect. The middle and posterior legs are held close to the sides. When the beetle gets to shore it dries itself carefully, curling its abdomen upwards, and using its middle and back legs. I have seen it frequently when on a leaf or some other floating raft enter the water and deliberately swim to the bank. At times, especially if a beetle has been kept for some time in a wet tube, it appears to become waterlogged and remains at the bottom of the water with its legs doubled up, and probably drowns. I have confirmed the experiments of the above observers by cutting off the end of the abdomen. A careful study of the glands and the fluid they secrete would be of great interest. I have little doubt the glands are analogous to those of *Bembidium* and *Myrmedonia*.

I have experimented with a fair number of other species of Coleoptera, especially of the genus *Stenus*. It seems probable that most of the latter are able to "skim," but some do it far more readily than others. It is important to experiment on these insects directly they have been captured, and with as little handling as possible, as a negative result would be of no value if they have been "bottled" for some time. Of the species with which I have experimented perhaps *S. guttula* is the most expert "skimmer"; it moves so rapidly on the surface of the water that it is really difficult to follow with the eye. *S. bipunctatus* also skims very readily, especially on a sunny day. By repeatedly and quickly throwing a specimen out as soon as it had got to shore I computed that it had skimmed quite twenty feet before I lost it, when, however, I think it was almost exhausted. This species when washed out by throwing water on to the bank at the side of a pond took deliberately to the water and "skimmed" to another part.

Of other members of the genus *Stenus* I have experimented with the following :—

S. ossium, *S. flavipes*, *S. picipes* and *S. tarsalis* skimmed more or less strongly on several occasions; the last very easily freed itself of the water and floated on the surface. These species did not generally start skimming at once, and often required some slight stimulation. I failed to get *S. juno* to skim, but when the last segment of the ab-

domen was cut off this moved very rapidly, as was also the case with *S. brunnipes*. I did not induce any of the following to skim: *S. declaratus*, *S. lustrator*, *S. buphthalmus*, *S. bimaculatus*, *S. providus* and *S. opticus*. I was unable to experiment with enough specimens of some of these species (only one in the case of *S. opticus*) to definitely conclude that they cannot skim, except in the case of *S. buphthalmus*. On many occasions I tested this species under the most natural conditions and in bright sunshine with negative results. Among other genera I found one species which possesses this special power of locomotion, viz. *Anchomenus albipes*. When thrown on the water this species swims very strongly with the fore and middle legs, using the back ones very slightly or not at all. By this method it progresses at a good speed, but if carefully watched it will be occasionally seen to give a distinct but short spurt forwards, which however is sometimes rather more prolonged. The legs are kept moving all the time, but the spurt forward is undoubtedly due to skimming, and when the apex of the abdomen is cut off it is found to skim for a short time. The beetle does not seem able to skim for long at a time, and those kept in a bottle for a short time refused to do so at all. There are many other closely allied forms and waterside species which might prove to possess the power of skimming if they were tested.

A great number of beetles gain land when flooded out by swimming, and some land beetles are very strong swimmers. Here again there is much to be learnt as to the exact method of swimming each species adopts. The members of the genus *Bembidium* upon which I have experimented (*B. assimile*, *B. articulatum*, *B. nitidulum*) swim very well. When *B. assimile* was flooded out by gradually immersing a piece of turf it took to the water quite naturally, and swam at a wonderful speed, moving the legs very rapidly as in running, the front legs which do nearly all the work being well spread out, the back legs being sometimes held still and crossed behind. *Badister bipustulatus* also swims well, using all its legs, the back ones often very strongly.

Most of the *Steni* are good swimmers, even those that also skim; *D. coerulescens*, *S. guttula* and *S. bipunctatus* progress almost entirely by skimming, however. *S. bimaculatus* moves quite rapidly by swimming and uses its front legs well spread out in a horizontal plane, as in *Bembidium*.

It also wriggles its body, which no doubt helps it along to some extent. *S. providus* swims much like the last. *S. juno*, *S. tarsalis*, and *S. lustrator* swim well, but *S. declaratus*, *S. flavipes* and *S. buphthalmus* were more sluggish in their actions. *Chilopora longitarsis* swims very readily, using its back legs strongly.

These are, of course, all more or less waterside species, and one would expect them to be good swimmers. Some waterside species, however, are almost helpless when on the surface of the water, and this is specially the case with the *Staphylinidae*. *Quedius mauroriufus* hardly progresses at all by ineffectual wriggling of its body, yet it is commonly found in company with *D. coerulescens* in moss at the sides of waterfalls. *Evaesthetus* is quite helpless, but all very small species are much affected by capillary attraction, being drawn to small pieces of stick, etc., and are quite unable to get a start off. *Dyschirius globosus* has great difficulty in overcoming this attraction, and then only swims feebly, using all the legs alike as in walking. *Tachypori* move their legs, which are well spread out, rapidly, but make quite slow progress. *Trogophloei* and *Homalotae* also swim, but are much affected by capillary attraction. *Oxypoda vittata* only ineffectually wriggles its body.

Quedius vexans, which often gets washed out of moles' nests in low-lying districts and is not uncommonly found in flood rubbish, struggles violently with a great deal of the body, and gets along at a fair rate, chiefly by using the forelegs very rapidly; the middle legs are not moved so fast, and the back legs only occasionally. The front legs are moved in a vertical plane, as is the case with a dog, only they are never lifted out of the water. *Q. fuliginosus*, *Heterothops nigra* and *Stilicus affinis* behave like *Q. vexans*.

Besides swimming there is yet another method of progress, viz.—walking on the water. *Stenus juno* on several occasions deliberately cleared itself of the water, and walked with its tarsi on the surface of that element. It first raised the front part of its body on the anterior and middle tarsi; the abdomen being afterwards cleared with the help of the back legs. *S. opticus* very easily cleared itself of the water and walked on the surface with the abdomen high in the air. Occasionally it allowed the abdomen to touch the water, but then always stopped for

a moment to dry it. When *Gnypeta labilis* was flooded off a piece of grass, it remained standing on the water with the abdomen curled up over the body. In this attitude it was blown along at a surprising speed by a very slight breeze. It also took flight directly from the water.

As might be expected a great many species of Coleoptera, which must only very accidentally find themselves in water, are quite helpless when they get there; among them I may mention, *Rhizobius litura*, *Hypera nigrirostris*, *Apion*, *Oxytelus*, etc. *Drusilla canaliculata* lay motionless for some time, then after some trouble cleared itself of the water enough to swim, keeping the antennae raised and constantly moving. *Myrmedonia collaris* behaved in much the same way, floating to the top in the form of an S with the underside of the abdomen uppermost, and remaining in this position for some minutes.

Bradfield, Berks, February 5, 1910.